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AUTHOR Goetz, Ernest T.; And Others
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ABSTRACT

Associative theory characterizes the memory's representation of a sentence as a collection of independently linked concepts. In contrast, Gestalt theory says that the representation underlying each proposition expressed in a sentence is an integral unit. A review of research indicates that previous results either have been equivocal or have supported the Gestalt position. Three new studies show that, when scored for gist, the propositions underlying simple three-word sentences are recalled completely or not at all. Another experiment indicates that one-proposition sentences containing four content words are more likely to be recalled as a whole than three-proposition sentences of the same length, and that fragmentary recall of the three-proposition sentences usually preserves the unity of constituent propositions. These results strongly support the Gestalt position over any associative model that has been proposed. (Author/RL)

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Technical Report No. 144

THE REPRESENTATION OF SENTENCES IN MEMORY

Ernest T. Goetz, Richard C. Anderson,
and Diane L. Schallert

University of Illinois at Urbana-Champaign

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University of Illinois
at Urbana-Champaign
51 Gerty Drive
Champaign, Illinois 61820

Bolt Beranek and Newman Inc.
50 Moulton Street
Cambridge, Massachusetts 02138

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Dr. Goetz is now located at Texas A & M University, Dr. Schallert is now located at the University of Texas.

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Abstract

Associative theory characterizes the memorial representation of a sentence as a collection of independently linked concepts. In contrast, Gestalt theory says that the representation underlying each proposition expressed in a sentence is an integral unit. A review of research is presented that indicates that previous results either have been equivocal or have supported the Gestalt position. Three new studies are reported that show that, when scored for gist, the proposition underlying simple three-word sentences are recalled completely or not at all. A final experiment indicates that one-proposition sentences containing four content words are more likely to be recalled as a whole than three-proposition sentences of the same length, and that fragmentary recall of the three-proposition sentences usually preserves the unity of constituent propositions. These results strongly support the Gestalt position over any associative model that has been proposed.

The Representation of Sentences in Memory

Most of the theorizing about human memory can be boiled down to just two basic conceptions. The first, associationism, traced back at least to Aristotle, was championed by the British associationists, and dominated American psychology for more than half a century. The approach is reductionistic and atomistic. All knowledge is said to be reducible to a set of simple elements that are connected by simple mechanistic links, or associations. The second approach, Gestalt psychology, developed by Koffka and Kohler, emerged as a reaction to British empiricism and associative psychology. Although Gestalt psychology never developed the grip on the field nor the explicit and elaborate models enjoyed by associationism, it has provided a genuine alternative. According to the Gestalt conceptualization, the fundamental units of human perception and memory are complex wholes that have emergent properties which make them irreducible into simpler elements. That is, "the whole is more than the sum of its parts."

While the early battlegrounds for the two approaches lay in perception and introspection, J. Anderson and Bower (1971, 1972, 1973; J. Anderson, 1976) have recently revived the conflict in the arena of sentence memory. A key assumption of prominent associative models is that sentences are represented as sets of independently linked concepts. In contrast to this atomistic conception, the Gestalt hypothesis is that each idea, or

proposition, expressed in a sentence is a well-formed whole. Once encoded into memory, a proposition tends to resist decomposition into elemental constituents. These two theories about the underlying memory representation for sentences lead to opposing predictions about several aspects of sentence recall. This paper will review the evidence from sentence recall studies which have tested these predictions, and present several new experiments.

Special attention will be paid to the Human Associative Memory model (HAM) of J. Anderson and Bower (1973). This has been by far the most influential model of sentence memory. A history of this field over the past decade would be a recounting of the attempts to test predictions of HAM. J. Anderson (1976) has developed a successor to HAM called ACT. Little will be said about ACT, largely because its predictions in the areas of sentence memory with which this paper is concerned are less clear-cut than HAM's. It should be emphasized, though, that most of the fundamental assumptions of ACT and HAM are the same. Indeed, HAM is representative of an entire class of associative models. Later a somewhat different associative model proposed by Jones (1978) will be discussed in detail.

J. Anderson and Bower have employed three strategies for testing associative and Gestalt hypotheses of sentence memory. The first examined the repetitions of a single word in several sentences. J. Anderson and Bower (1971) reported a study in which the verbs in SVO sentences appear

in 1, 2, 4, or 8 sentences. Figure 1 indicates the HAM structure which would result from a complete encoding of two sentences with a common verb. The graph terminates in type nodes representing underlying concepts.

Insert Figure 1 about here

These are connected to the token nodes that represent occurrences of the indicated words in sentences via the membership relation. J. Anderson and Bower argued that object recall when cued with the subject noun should be unaffected by verb repetition. This is predicted because the verb does not lie on the path between the subject and the object.

Consider next the case where the learner fails to recall either the verb or the object when cued with the subject noun. According to HAM, such a recall failure will occur only when one or more links are missing in the path between the subject and the verb and also one or more links are missing in the path between the subject and the object. If the learner is then cued with the subject and the verb of the sentence, he will only be able to recall the object if there is an intact path between the verb and the object. The subject of the sentence can contribute nothing to object recall, since if there had been an intact subject-object path, the learner would have recalled the object when cued with the subject alone. J. Anderson and Bower (1971, p. 676) state that:

> If the verb has occurred in several sentences . . . the S will probably not be able to select with certainty the correct path from the verb type to the appropriate object. The S in this

predicament would have to guess among several equally likely paths from the verb type. Hence, conditional upon non-recall of both verb and object to the subject-only cue, the model predicts confusion or object-competition will increase and correct recall decrease as the verb occurs in progressively more sentences.

It was this prediction which provided a contrast between associative and Gestalt views and was the focus of the study. Anderson and Bower maintained that the Gestalt hypothesis would predict that verb repetition would not produce any interference, even when the subject prompt alone failed to produce any recall. Their claim was that, since each sentence had a different subject and object, each should constitute a unique and unconfusable whole despite verb overlap.

Sentences were presented in two lists of 32 sentences that contained eight sentences which had different verbs, eight sentences formed by using four verbs twice, eight sentences using two verbs four times, and eight sentences which shared a single verb. Each sentence was cued twice; the subject noun cue tested recall of the verb and object, which was immediately followed by the subject-plus-verb cue for object recall. As expected, verb repetition had no effect on object recall when cued by the subject noun alone. More importantly, the crucial prediction came out in favor of associative theory. That is, the probability of correctly recalling the object to the subject plus verb cue, conditional upon having

recalled nothing to the subject noun alone, decreased as the number of verb repetitions increased.

A second pair of opposed predictions from the associative and Gestalt positions were also tested. Since by the associative account, the learner must guess between a number of equally likely candidates when trying to recall the object from the subject and verb when the subject alone failed, the number of object intrusions should increase with number of verb repetitions. In contrast, according to J. Anderson and Bower's version of the Gestalt theory, each sentence was unique and unconfusable, and therefore, no increase in intrusions was expected. These predictions were tested by counting the number of "intragroup intrusions." For each of the four verb repetition conditions, intragroup intrusions were defined as the intrusion of one of the eight objects from sentences in that condition to an inappropriate subject-verb cue. Intragroup intrusions showed the predicted increase. Thus, two experimental tests supported the associative theory at the expense of the Gestalt hypothesis. These results were crucial because this study was the first in a series which led J. Anderson and Bower to abandon their initial Gestalt intuitions in favor of the development of associative models of human memory (cf. J. Anderson & Bower, 1973, p. 332). Further, J. Anderson (1976, p. 407) pointed to these results as exemplifying the only type of evidence favoring the associative over the Gestalt conception which has not been disputed.

It seems to us, however, that J. Anderson and Bower (1971) did not adequately test associate theory. According to the passage quoted above, the theory predicts that in order to recall the object given a subject-verb cue, when the subject alone produced no recall, the learner must guess between several equally likely alternatives. The number of alternatives is determined by the number of sentences which share the verb. Since the subject alone failed to produce any recall, it can not aid in this process, so there can be no bias toward the correct object. The correct object should occur with the same frequency as the intrusion of any one of the other objects which share that verb, each of which should be intruded equally often. Thus, the probability of correctly recalling the object given the subject-verb cue, when the object was not recalled given subject alone (N), will be an inverse function of the number of sentences in which the verb is repeated (R) and a direct function of the conditional probability of recalling any object (A) which shares the verb. That is:

$$P(O|SVN) = P(A|SVN)/R \qquad (1)$$

Equation (1) formulates the proper test of associative theory. The prediction that J. Anderson and Bower evaluated is simply too oblique to provide an adequate test. The test for increased intrusions is also inadequate, since the theory allows the more precise statement that each object that shares the verb should be intruded with the probability $P(A|SVN)/R$.

Unfortunately, the data were analyzed in a manner which makes proper evaluation of the results impossible. The strong test of the theory requires that intrusions of objects which share a common verb be counted. J. Anderson and Bower, however, counted "intragroup" intrusions which included intrusions of objects which shared a verb plus other objects from sentences with different verbs which appeared in the same repetition condition. This scoring system misses the point. Thus, neither of the two associative hypotheses discussed above can be tested with the reported data, and the study provides only tangential evidence for associative theory. Although other studies showing interference from repeating a word have been reported (J. Anderson & Bower, 1973, Chapters 12 & 15; J. Anderson, 1976, Chapter 8), none has specifically contrasted associative and Gestalt theories.

Further, it is inappropriate to argue, as have J. Anderson and Bower, that any evidence of interference produced by verb repetition is counter to Gestalt theory. Such a claim rests on the assumption that Gestalts are never confusable. This assumption is not necessary nor is it reasonable. Faces and houses qualify as visual Gestalts. Yet they can be confusable, as anyone who has attempted to recognize a distant and little known cousin from a large family, or to locate the home of a casual friend in a housing development, can attest. Nonetheless, Gestalt theory, as formulated by J. Anderson and Bower (1972), does make a testable prediction about the effects of verb repetition. If the sentence is functioning as a holistic unit with emergent properties, then the subject plus the verb

should make a more effective cue than is predicted by the associative account. That is, there should be a bias toward recall of the correct object whereas associative theory dictates that the subject noun in the compound cue can contribute nothing. Thus, the Gestalt hypothesis predicts:

$$P(O|SVN) > P(A|SVN)/R \qquad (2)$$

where associative theory predicts equality. Unfortunately, once again, the prediction can not be evaluated using the data reported.

A second line of research directly addressed the issue of whether compound cues are effective in indexing recall over and beyond that which would be expected from considering their elements separately. Included here are the "crossover" experiments of J. Anderson and Bower (1972). The basic approach was to present people with pairs of sentences which shared a common object, such as The child hit the landlord and The minister praised the landlord. The resulting HAM structure for a complete encoding of this pair is shown in Figure 2. After the presentation of a list of such sentences, recall was cued with the subject or verb alone, or a

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Insert Figure 2 about here

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subject-verb compound. This compound cue could come from the same sentence (e.g., The child hit) or different sentences (e.g., The child praised). The task was always to recall the object noun. According to

the model, a compound cue will prompt recall if there is an intact path from the subject to the object, or if there is an intact path from the verb to the object. For compound cues drawn from different sentences (S_1V_2), the two paths to the object do not overlap (share any links), so the two probabilities are independent. Therefore, the probability of recalling the object when given a compound cue from different sentences is:

$$P(O|S_1V_2) = P(O|S) + P(O|V) - P(O|S)P(V|S) \qquad (3)$$

However, when both elements of the compound cue come from the same sentence (S_1V_1), the two paths to the object overlap, so the probabilities of intact paths are not independent. Hence, when the retrieval power of the two compound cues is compared, the prediction is that:

$$P(O|S_1V_1) \leq P(O|S_1V_2) \qquad (4)$$

and it also follows that:

$$P(O|S_1V_1) \leq P(O|S) + P(O|V) - P(O|S)P(O|V) \qquad (5)$$

It should be noted that these predictions do not depend upon the particular structures posited by HAM, but follow from any associative model that assumes independent associations and has overlapping paths for compound cues from the same sentence and nonoverlapping paths for different sentences.

The Gestalt hypothesis is that the sentence has emergent properties which make it more than the simple sum of its parts. Therefore, J. Anderson

and Bower asserted, since same-sentence compounds are more similar to the original Gestalt than single word cues, they should benefit from configural effects. The compound cues drawn from different sentences destroy the configuration and should not be nearly as effective. Therefore, the direction of inequalities (4) and (5) should be reversed.

J. Anderson and Bower (1972) reported four experiments in which these predictions were tested. In Experiments 1 and 2, subjects were told to study the sentences for a recall test. The trends in the results were consistent with the associative predictions, although tests of inequalities (4) and (5) were not significant. In Experiments 3 and 4, subjects were not told of the memory test, but were asked to generate continuations during study. In these experiments, the Gestalt predictions prevailed. J. Anderson and Bower explained these latter results by arguing that the continuation was added to the memory trace and that the person would be able to spontaneously generate it at recall given part of the sentence. The continuation could then serve as a cue for associative retrieval of the object. Although this explanation is totally ad hoc and at odds with the spirit of associative theory, J. Anderson and Bower were so confident of it that they omitted mention of the offending studies in the HAM book (J. Anderson, 1976, p. 415).

Since that time, Foss and Harwood (1975) have reported two experiments in which, as a cover task to promote deep processing, subjects rated

the meaningfulness of the sentences during study. In both of these studies, and in two more by J. Anderson (1976, Chapter 10, Experiments 1 and 3), in which meaningfulness ratings were employed, the Gestalt predictions prevailed. Thus, as J. Anderson (1976, pp. 416-417) points out, whenever study instructions ensure that subjects will process the sentences meaningfully, the Gestalt hypothesis is supported. J. Anderson explains this result in terms of encoding specificity. That is, words have different senses, and a word in a sentence will be encoded in the sense appropriate to other words in the sentence. With the compound cue, some of the context will be available to guide the learner to the appropriate sense. Single word cues are less likely to access the contextually appropriate sense. Since recall will occur only if the encoding of the cue matches its encoding during study, configural effects are predicted. Such an explanation, however, commits the theory to a very large number of senses, indeed, and cannot really save associative theory (see R. Anderson & Ortony, 1975). A different account of these results has been offered by Jones (1978), to which we shall return.

To summarize what has been covered up to this point, two types of tests contrasting associative with Gestalt theory have either failed to properly address the issue or have supported the Gestalt conception at the cost of associationism. The third and final test of whether sentences are represented as collections of independent associations or holistic ideas is the most fundamental. While associative theory predicts fragmentary

recall of even SVO sentences, Gestalt theory predicts that the ideas underlying such sentences should be recalled holistically. Sharply conflicting results have been reported by J. Anderson and Bower and by R. Anderson. We shall review these studies and then report three new experiments.

Associative theory predicts holistic recall of an SVO sentence only when a complete associative network of the sentence has been encoded and is available at recall. Missing links may cause either partial recall (as when the S link is missing and recall is cued with the verb or object) or total recall failure (as when the S link is missing and recall is cued with the subject). The important point is that representation of sentences as collections of independently linked concepts commits associative theory to the prediction of a relatively high level of partial recall. According to Gestalt theory, on the other hand, instances of partial recall will be rare events. J. Anderson and Bower (1971) first addressed this issue in the verb repetition experiment described above. In that study, recall of both the verb and the object occurred to approximately 26% of the subject cues across all repetition conditions. Instances of one-word recall to subject cues ranged from 13% for sentences with unique verbs to 43% for sentences in which the verb was used eight times. J. Anderson and Bower (1973, Chapter 10) reported a study in which recall of location-subject-verb-object sentences (e.g., In the park the hippie touched the debutante) was cued with one of the four content words. In

this study, 12% of the cues produced recall of all three remaining content words, while partial (one- and two-word) recall occurred to 24% of the cues.

While the high level of partial recall reported in these studies appears to support associative theory, there is reason to question the results. In the verb repetition experiment, the learners may have become aware of the manipulation. For the conditions in which verbs were repeated in several sentences, a learner might choose to ignore the sentences as meaningful wholes and focus on the verbs. Such a learner could recall something to subject cue by outputing one of the repeated verbs, thereby producing partial recall. That some learners may have adopted this strategy is suggested by the increase in verb-only recall with increasing verb repetitions. The sentences containing four content words that were employed by J. Anderson and Bower (1973) may have been too complex to produce holistic recall. If these sentences were analyzed into propositions in Kintsch's (1974) system, they would consist of two propositions. Thus, partial sentence recall might have been observed even though the constituent propositions were recalled holistically.

More important objections to these studies have been raised by R. Anderson (1974). In all the studies cited above, J. Anderson and Bower employed verbatim scoring. It is well known that memory for the meaning or gist of a sentence or text may remain long after the exact words or phrasing have been forgotten. Verbatim scoring, therefore, may classify

as partial recall instances in which the gist of the sentence is recalled holistically. Furthermore, instructions which stress verbatim recall at study or at recall may cause the learner to attempt to treat the material as word strings rather than as meaningful sentences, or to surpress recall of a sentence element if only the gist and not the exact wording is remembered. Either strategy would bias the results toward partial recall.

R. Anderson (1974) reported a study in which he investigated whether the gist of simple SVO sentences is recalled holistically. Initial processing of the sentences was manipulated by instructing the learners either to read the sentences over silently three times (to encourage rote memorization) or to form mental images of the events described in the sentences (to encourage meaningful, integrative processing). Recall, cued by the subject noun, was tested immediately or 24 hours after the study of a list of 16 sentences. At recall, instructions assured the learners that answers would be counted correct if they expressed the ideas of a sentence, even if the wording was changed. The instructions stressed that the learners should recall as much as possible, and that they should be sure to write down any part of a sentence that they could remember, even if they could not remember all of it. A scoring system which counted both verbatim and gist recall was employed. Gist recall was divided into four classes of semantically related words: synonyms, superordinates, hyponyms (i.e., subordinates), and cohyponyms (e.g., rifle recalled for pistol). While neither study instruction nor retention interval affected

the level of verbatim or gist recall, the proportion of gist recall accounted for by semantically related words increased at the longer retention interval. More importantly, while verbatim scoring showed 26% total recall and 20% partial recall, substance scoring revealed 47% total recall as compared to only 4% partial recall. Describing the results another way, when substance scoring was employed, whole sentence recall accounted for 96% of all words recalled.

These results support the Gestalt hypothesis when one looks at substance recall. However, J. Anderson (1976, p. 411) has reported that he found a relatively high level of partial recall of SVO sentences even when substance scoring is employed. The purpose of the first experiment was to provide a further test of the level of partial recall for simple SVO sentences, in the hope of resolving this issue. In constructing the materials, special care was taken to avoid the use of conceptually well-integrated sentences for which prior knowledge or prior associations between words might bias the results in favor of holistic recall (cf. Rosenberg, 1968).

Experiment 1A

Method

Subjects. The subjects were 74 undergraduates enrolled in an introductory psychology class, who participated in order to fulfill a course requirement.

Materials and design. Sentences were constructed in the following manner. First, 509 nouns and 395 transitive verbs were chosen at random from the Thorndike-Lorge (1944) list. Next two nouns and a verb were selected at random from these pools. The attempt was made to construct a nonanomolous simple declarative sentence. When it was judged that a sensible sentence could not be made, the words were returned to the pool. Finally, 80 sentences created in this manner, along with 10 clearly anomolous ones, were rated for sensibleness on a four-point scale by 48 undergraduates. The 60 sentences rated most sensible were employed in the experiment. Using these procedures, sentences such as the following were generated:

The clerk surprised the dog.

The general recognized the coin.

The giant claimed the lake.

The pupil admired the goose.

All of the selected sentences were rated on average as having a clear meaning. The agents, verbs, and objects of the final 60 sentences did not differ significantly in Thorndike-Lorge frequency, $F(2,177) = 2.00$.

The sentences were randomly divided into two 30-sentence lists, and these in turn were split into three 10-sentence sublists. Sublists were used to counterbalance cue type with sentences. For each subject, one sublist each was cued with the agent, verb, and object, and across all subjects, each sublist was cued with each type of cue for one-third of

the subjects. The lists were further organized into blocks such that half of the items in each sublist were in each block. The first block presented was the first block tested. The purpose of the blocking procedure was to minimize recall from short-term, nonsemantic memory. Within blocks, sentence and cue orders were independently randomized.

Procedure. Subjects received both lists in counterbalanced orders. Sentences were presented at a 7-second rate, via tape recordings prepared by a male radio-TV announcer, to groups of about 30 subjects. After each list, subjects completed a test in the form of a mimeographed booklet with one cue per page.

Preliminary instructions indicated that, "It is more important that you grasp the ideas expressed in the sentences, than it is for you to memorize their exact wording." The recall instructions reiterated this point, and also stressed that, "If you cannot remember the whole sentence, give any part you can remember." This latter sentence was underlined on the subject's copy and emphasized by the experimenter as she read the instructions aloud.

Scoring. Protocols were scored for both verbatim and substance recall. Verbatim scoring allowed only abbreviations (e.g., TV for television) and changes in number or tense. Substance scoring included four classes of semantically related words substituted for the language of the original, namely synonyms, close superordinates, hyponyms, and close cohyponyms (cf. R. Anderson, 1972, 1974). The procedure was to

prepare rosters of all nonverbatim words which appeared in the recall protocols. Three judges then classified each response, considering the original sentence but without knowledge of the rest of the response for that sentence. Finally, the protocols themselves were scored. This was simply a clerical task because the responses had been exhaustively classified at the preceding stage.

Results

Table 1 shows the proportion of words recalled at each scoring level, when cued by the agent, verb, and object. If recall were perfectly all-or-none, then for each cue the proportions of the two remaining words should be equal, and both words should be recalled as often as either of them is recalled. Overall, on the substance measure, recall of exactly one word constituted 6.1% of all possible recalls, as compared to 23.4% in which both words were recalled and 70.5% for which neither word was recalled. Instances of two-word recall accounted for 88.5% of all words recalled. Clearly there is a strong tendency toward all-or-none memory. Another type of evidence is the contingency between two words recalled to a particular cue. The condition in which the agent was the cue is representative of the data. When the agent was the cue, the probability of recalling the verb given that the object was recalled was .893, while the probability of recalling the verb given that the object was not recalled was .032. These results fit quite well with those of R. Anderson (1974), who obtained the values .959 and .039 respectively for the two

conditional probabilities, but contrast with those of J. Anderson (1976, p. 411), who reported probabilities of .589 and .031 for recall of the verb when cued with the object, conditional upon recall or nonrecall of the object.

Insert Table 1 about here

Finally, two tests were conducted of the HAM hypothesis that the verb and object are more closely associated than is either with the agent. Since fewer links must be traversed, recall of the verb should be better when cued by the object than by the agent. For the substance measure, marginal support was found for the hypothesis, $\underline{F}_1(1,146) = 4.12$, $\underline{p} < .05$, $\underline{F}_2(1,118) = 2.15$, min. $\underline{F}'(1,124) = 1.41$. A second prediction is that the verb cue is more likely to elicit recall of the object than of the agent. The support for this prediction was also equivocal, $\underline{F}_1(1,146) = 6.35$, $\underline{p} < .05$, $\underline{F}_2(1,118) = 1.78$, min. $\underline{F}'(1,182) = 1.39$.

Experiment 1B

Clearly, the very high level of holistic recall in Experiment 1A supported the Gestalt hypothesis of sentence representation. However, due to the record of conflicting results on this issue, we felt it advisable to attempt to replicate these results. A second reason for another experiment was to modify the level of learning. Arguments about sentence memory (J. Anderson, 1976, pp. 410-411; Foss & Harwood, 1975; Jones, 1978)

have often hinged on the assumption that the amount of whole sentence encoding will vary with overall level of learning. Level of learning was varied simply by changing list length. We were also troubled by the number of intralist intrusions in 1A, so the procedure of the replication study was modified slightly in order to reduce this problem.

Method

Four lists of 15 sentences were constructed so as to minimize semantic overlap between sentences within each list. This procedure was designed to decrease intralist intrusions and increase the level of recall in the cued recall test that immediately followed each list. The materials and procedure were otherwise the same as in Experiment 1A. Ninety-three introductory psychology students participated as subjects.

Results

Table 2 shows the proportion of words recalled for each cue. Overall, recall of exactly one word occurred 7.0%, recall of both words 41.7%, and total recall failure 51.3% on the substance measure. Instances in which both words were recalled accounted for 92.3% of all words recalled. Looking at a representative interword contingency, when a sentence was cued with the agent, the probabilities of recalling the object were .912 and .045 conditional upon recall or nonrecall of the verb. Again recall was largely all-or-none.

Insert Table 2 about here

The HAM prediction that the object would prove more effective at cueing the verb than would the agent did not approach significance, $F_1(1,184) = 1.04$, $F_2(1,118) = .68$, min. $F' < 1$. For the prediction that the verb would be a better cue for the object than for the agent, $F_1(1,184) = 1.03$, $F_2(1,118) = .60$, min. $F' < 1$. Thus, contrary to the trend in Experiment 1A, no support was found for HAM's subject-predicate distinction.

Experiment 2

It is possible that, despite the precautions taken to control for conceptual integration, the materials used in 1A and 1B exhibited, on average, a greater degree of prior association between the verb and subject than between the verb and object noun, and that it was these pre-experimental influences that accounted for the failure to support the structure posited by HAM. The quasi-random procedure did not ensure that subject and object nouns were equated. Subject nouns were more likely to be animate, suitable for the agent role. This difference may have spuriously increased the strength of the relationship between the subject noun and verb, biasing the results against HAM. Because of problems of this type, a strong test of the subject-predicate distinction would require that subject and object nouns be precisely equated. Reversible sentences were employed in Experiment 2 in order to provide such a test. In reversible sentences subject and object nouns are perfectly equated, since across sentence pairs the same nouns serve both as subject and object for each verb.

Method

Subjects. The subjects were 36 students in an undergraduate educational psychology class who participated as part of a class requirement.

Materials. Twenty-four sentence pairs were constructed so as to be sensible with either noun serving as the subject. For example:

The demonstrator hit the car.

The car hit the demonstrator.

The robber surprised the security guard.

The security guard surprised the robber.

The sentence pairs were randomly assigned to two sublists of 12 pairs. Two versions of each sublist were constructed by randomly dividing each sentence pair. The sentences were printed on quarter sheets, one to a page and assembled in booklets in 4 different random orders.

In addition to the experimental sentences, two filler sentences per list appeared as the last two pages of each study booklet. The filler sentences were not tested. They served as interpolated material for the purpose of reducing short-term memory effects.

Memory for the sentences was tested by presenting the verb of each sentence as a cue. The test booklets were made up of the 12 verbs presented in individually randomized orders.

Design and procedure. Half of the subjects studied each version of a sentence, and each subject studied both sublists in counterbalanced

orders. The study instructions emphasized that subjects should go through the booklet in order and read and think about each sentence as they would later receive a memory test. The sentence study interval of 10 seconds was regulated by tape recorded beeps which signaled the subjects to turn the page to the next sentence. Immediately after each sublist, recall was cued with the verbs.

Results

The protocols were scored for substance recall of the subject and object nouns. In addition to verbatim responses, the substance criteria accepted synonyms, hyponyms, close cohyponyms, and close superordinates.

The proportion of substance recall was slightly higher for subjects than objects (.65 vs. .64), although this difference did not approach significance. Thus, a strong test of the subject-predicate distinction, in which possible subject-object confoundings were controlled, gave no support for the HAM structure, because recall was almost exclusively holistic, accounting for 96% of all words recalled.

General Discussion

The three studies reported here, as well as earlier experiments by R. Anderson (1974), have shown that the gist of simple sentences is recalled holistically. This result obtained over a fairly wide range of levels of recall: roughly twice as many words or sentences were recalled in Experiment 1B as in Experiment 1A, yet the same degree of holistic

recall was observed in both. Thus the suggestion that the extent of holistic recall is tied to recall level was not borne out. While J. Anderson has stated that "Whether one is going to consider this degree of all-or-none recall as evidence for a Gestalt theory is a matter of taste" (1976, p. 411), and that, in any case, "the Gestalt versus associative issue is not really decideable on the basis of empirical data" (1976, p. 407), we believe that these studies provide strong support for the Gestalt hypothesis at the expense of models positing independent associations.

J. Anderson (1976) has invoked individual differences in order to permit associative models to accommodate holistic recall:

> We assume that subjects varied in their abilities and that they varied in the amount of effort they expended memorizing individual sentences. This meant that for some sentences for some subjects all associations had a high probability of being formed while for other sentences for other subjects all associations had a low probability. These individual differences meant that there would be more all-or-none recall than expected by chance, producing contingencies in the data. The fact that probabilities of forming links covary over individuals and sentences make it virtually impossible to reject an associative model on the basis of amount of all-or-none recall. (J. Anderson, 1976, p. 410)

Available data plainly show that a simple appeal to individual differences will not salvage an independent associations theory. First of all, there are the alternative analyses of the results of the five experiments reported by J. Anderson and Bower (1972). Taking individual differences into account had almost no effect. Second, Foss and Harwood (1975) took account of individual differences and still got results that strongly contradicted associative models. Third, R. Anderson (1974) estimated for each individual subject the parameters for each of the independent links assumed in a HAM representation. When gist scoring was used, the means of two of the three parameters approached 1 and their variances were vanishingly small. According to HAM, the proportion of sentences in which both the verb and the object will be recalled given the subject as a cue is the product of all three parameters. However, one of the parameters correlated almost perfectly (.97) with this proportion, so the other two could be dropped with little loss of information. R. Anderson (1974, p. 537) concluded that this analysis of individual variation substantiated the case that "subject-verb-object sentences are learned and recalled as propositions on a whole-or-none basis."

Experiment 3

We have argued that the underlying meaning of a simple SVO sentence is represented in memory as a Gestalt, or emergent whole, as evidenced by all-or-none recall of the gist of the sentence. It is, however.

unreasonable to expect holistic encoding of complex sentences. It simply does not make sense to expect people to recall sentences like the following in an all-or-none fashion:

> Helen, the most promising graduate student at the University of Northwestern Illinois, quit school to join the circus, but lived to regret it.

Clearly, the irreducible units of such sentences, if they exist, must exist at some simpler level. Propositions have repeatedly been suggested as the basic unit for the representation of text in memory. Thus, while the sentences above will not be recalled holistically, constituent propositions such as Helen quit school may well be. The purpose of the next study was to test whether propositions in slightly more complex sentences are recalled holistically.

Experiment 3 relied on Kintsch's (1974) system of propositional analysis. According to Kintsch, a proposition consists of a predicator and one or more arguments. Predicators include concepts such as those expressed by verbs, modifiers, relational terms, and superordinates. Arguments are most often realized as nouns, but the use of propositions as arguments enables the representation of propositional embeddings. The system is based on Fillmore's (1968) case grammar, the arguments filling cases such as agent, instrument, and object.

Like the present authors, Kintsch has postulated that propositions are the units of sentence memory and has attempted to empirically validate

this claim. Kintsch and Glass (1974) reasoned that if propositions are the units of memorial representation, then sentences which are composed of a single proposition should be more likely to be recalled in an all-or-none fashion than are sentences composed of multiple propositions. They reported two studies in which single-proposition sentences were more often recalled holistically than two- or three-proposition sentences, when the number of content words was controlled. Experiment 3 attempted to replicate and extend these studies. All of the sentences employed by Kintsch and Glass were conceptually well integrated. This raises the possibility that the results were biased in favor of holistic recall. Both well and poorly integrated sentences were employed in Experiment 3. While Kintsch and Glass studied only one type of three-proposition sentence, six different types were employed in the present study, along with three types of one-proposition sentence, in order to test for generality.

In our judgment, Kintsch's scheme is just about the simplest imaginable that has any chance of reasonable correspondence with the way people actually code sentences. Kintsch has achieved economy of representation in a number of ways. One is to assume that case relations can be specified in the abstract without reference to the use being made of particular verbs in particular contexts. Consider the following three sentences:

The artist handed the toddler the lipstick.

The scout carried the ham to the principal.

The ballerina put the slippers on her feet.

In Kintsch's system these are agent-verb-object-goal (AVOG) sentences. Each is assumed to express a single proposition. The first sentence does look as though it contains one propositon since the verb handed seems to demand both an object and a goal. You cannot say either The artist handed the lipstick or The artist handed the toddler. It is evident that the goal case is optional in the second sentence. The implication of this is that it may be better to conceive of to the principal as connected in a separate proposition. The third sentence is more complicated. It is possible to say The ballerina put the slippers on, which suggests that the goal case is not obligatory. However, the argument could be made that put on does require a goal which, however, has the special property that it normally is highly predictable (hats go on heads, shoes go on feet, etc.). If this is true, her feet can be deleted because it is redundant. Thus, a subject in a memory experiment attempting to recall the third sentence might omit the phrase even though it expresses an integral part of the proposition.

The foregoing illustrations suggest that it will be no surprise if Kintsch's scheme turns out to give a less than perfect account of sentence memory. Even so, Experiment 3 provided at least a general test of the Gestalt hypothesis. The only requirement was the minimal assumption that sentences characterized in Kintsch's system as expressing three propositions are on the average propositionally more complex than sentences characterized as expressing one proposition.

Method

Design. There were two main factors; integratedness (integrated vs. unintegrated sentences), a between-subjects factor; and number of propositions per sentence (one vs. three), a within-subject variable. In addition, type of sentence was nested within number of propositions. There were three types of one-proposition sentences and six types of three-proposition sentences. Table 3 gives examples of integrated and unintegrated sentences of each type as well as the propositional representation in Kintsch's system.

Insert Table 3 about here

Subjects. The subjects were 74 undergraduates enrolled in psychology and educational psychology classes who participated as part of a course requirement.

Materials. All sentences were made up of four content words. There were 60 integrated and 60 unintegrated sentences. In addition, there were 40 filler sentences, 20 of each type. Integrated sentences were judged to characterize ordinary, unsurprising situations. In these sentences the actors, actions, and objects "go together." Unintegrated sentences were constructed by describing unlikely (but still possible) states of affairs. Judgments of integratedness were made by two native speakers of American English.

The sentences were constructed within the bounds of Kintsch's propositional representation system. For each level of integration, there were 30 one-proposition sentences (10 of each of 3 types) and 30 three-proposition sentences (5 of each of 6 types).

Subjects saw either the integrated or the unintegrated set of sentences. The sentences were printed individually on quarter-size sheets of paper and assembled into booklets. Every subject saw 10 booklets, each of which was made up of three one-proposition sentences, three three-proposition sentences, and two filler sentences. The sentences were randomly assigned to booklets, with the restriction that each of the three one-proposition types and three of the six possible three-proposition types were represented in each booklet. The order of sentences was randomized within each booklet, except that the filler sentences always occurred at the end. Their purpose was to eliminate short-term memory effects in free recall, which immediately followed each booklet. The order of booklets for each subject was determined according to a Latin square.

Procedure. An instruction sheet which explained the procedure enjoined the subjects not to look at any booklet until signalled, and informed them that a recall test would follow. The instructions stressed that accurate, although not necessarily verbatim, recall was desired. Pages were turned at 10-second intervals, signalled by beeps from a tape recorder. Immediately following the last sentence of each

booklet the subjects were given a free recall test. They were told to write each sentence, or any part thereof that they could remember, in any order. Recall of content words was scored according to gist criteria in which synonyms, hyponyms, close cohyponyms, and close superordinates as well as the exact words of the original were counted correct.

Results

Proportion of Content Words Recalled

The effect of number of propositions was significant by subjects, $F_1(1,72) = 7.89$, $p < .01$, but not by sentences, $F_2(1,116) = 1.95$, reflecting a trend toward better recall of one- than three-proposition sentences (.529 vs. .495). The effect of integration reached significance, $F_1(1,72) = 5.85$, $p < .05$, $F_2(1,116) = 11.34$, $p < .01$, min. $F'(1,142) = 3.86$, $p < .05$, with more words being recalled from integrated than unintegrated sentences (.553 vs. .474). The Number of Propositions x Integration interaction was not significant, $F_1(1,72) = 1$, $F_2(1,116) < 1$.

Proportion of Whole Sentence Recall

As one index of holistic recall, the number of words recalled from sentences in which all four content words were recalled was divided by the total number of content words recalled. As predicted, there was more whole sentence recall of one-proposition sentences (.760) than of three-proposition sentences (.676), $F_1(1,72) = 26.01$, $F_2(1,116) = 7.64$, $p < .01$, min. $F'(1,178) = 5.91$, $p < .05$. Surprisingly, although there was a

trend for more holistic recall of integrated sentences than unintegrated sentences (.747 vs. .691), the effect was not significant, $\underline{F}_1(1,72) = 2.68$, $\underline{p} = .11$, $\underline{F}_2(1,116) = 1.96$, $\underline{p} = .16$. The Number of Propositions x Integration interaction did not approach significance, $\underline{F}_1(1,72)$ and $\underline{F}_2(1,116) < 1$.

The results replicate those of Kintsch and Glass (1974, Experiment 1). In both the study by Kintsch and Glass and the present study, single-proposition sentences did not reliably produce better total recall of words but did significantly increase holistic recall.

The number of propositions in a sentence affected the likelihood of holistic recall of both well and poorly integrated sentences. These ranged from the mundane to the bizarre. What is most striking about the results is that the number of propositions has a significant effect on whole sentence recall, while conceptual integration, with all its intuitive appeal and face validity, failed to produce a significant effect. The trend of the results was consistent with the obvious prediction, and we do not wish to make too much of the failure to reach significance. The relative magnitude of the effects does, however, highlight the strength of the effect of number of propositions.

In order to further investigate the effect of conceptual integration on whole sentence recall and to test for differences between the sentence types employed in the study, separate analyses of one-proposition and three-proposition sentences were undertaken in which conceptual integration and

sentence type were included as factors. Nothing of special note appeared in the analysis of single-proposition sentences. Of some interest in the analysis of three-proposition sentences was an Integration x Sentence Type interaction, $F_1(5,315) = 7.19$, $p < .01$, $F_2(5,48) = 3.41$, $p < .05$, min. $F'(5,101) = 2.31$, $p < .05$. Of the six types of three-proposition sentences employed in this study, three (JJAV, JAVL, BJAV) contained modifiers while the other three (AVAV, AVLL, AVVV) did not. For each of the sentence types with a modifier, poorly integrated sentences exhibited greater whole sentence recall than well integrated sentences, while the reverse was true for the remaining sentence types. Table 4 shows the proportion of whole sentence recall collapsed across the three types of sentences with and without modifiers. For the sentences with two modifiers, deletions of one or both modifiers accounted for nearly

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Insert Table 4 about here

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all of the difference between the well and poorly integrated conditions. It may be that the modifers in some of the well integrated sentences were so redundant that subjects failed to encode them or failed to output them at recall. In the poorly integrated sentences, modifiers may have particularized the meanings of the sentences (cf. R. Anderson, Goetz, Pichert, & Halff, 1977) or enabled subjects to form bizarre mental images.

Proportion of Whole Proposition Recall

The question of primary interest here is whether propositions tend to be recalled all-or-none. The demonstration of an effect of number of propositions in a sentence on the recall of the whole sentence sheds only indirect light on the issue. In the analyses that follow, the holistic recall of propositions is examined directly.

Table 5 shows, for each three-proposition sentence type, the proportion of holistic recall of component propositions. When holistic recall of constituent propositions is considered, over 94% of the words recalled from the well integrated three-proposition sentence types are accounted for.[1] Even for poorly integrated sentences, holistic recall accounted

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Insert Table 5 about here

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for nearly 90% of all words recalled. For four content word sentences, there are 14 combinations of four content words taken one, two, or three at a time. Pooling across sentence types, only 31% of the possible partial sentence recall combinations would maintain the integrity of constitutent propositions, yet they contributed over 80% of the observed partial recall for the well-integrated sentences. We have reanalyzed some data from Kintsch and Glass, and found that for their three-proposition sentences, 93% of all words recalled represented holistic propositional recall.[2] Clearly there is a strong tendency toward holistic recall of propositions in the three-proposition sentences.

Holistic recall of propositions accounted for over 90% of the words recalled from three-proposition sentences, but only 76% of the words from single proposition sentences. Why was there such a disparity? A ready answer is that two or more propositions may underlie some of the sentences that are classified as expressing one proposition in Kintsch's system. Patterns of partial recall were examined in order to investigate this possibility. Overall, there were 218 instances that consisted of exactly three content words. These accounted for 66% of all words that appeared in partially recalled sentences. In most cases the three words formed an acceptable English sentence that expressed a coherent proposition. Furthermore, certain arguments were much more likely to be omitted than others. With respect to AVGO sentences, such as The customer wrote the company a complaint, and AVOI sentences, such as The housewife killed the roach with insecticide, it was the goal or the instrument that were most often deleted, producing recall of the form The customer wrote a complaint or The housewife killed the roach. This suggests that AVO is the core proposition and that additional arguments involving goals or instruments are joined in separate propositions. As we indicated earlier, though, we would not care to make a general claim of this sort apart from an analysis of specific verbs in context. However, here is not the place for a detailed examination of alternative schemes for representing the propositions in complex sentences. We shall content ourselves with the observation that it is apparent that the data can be accommodated gracefully by a propositional model.

Co-occurrence of Word Pairs

We have developed a metric to permit more fine grained analysis of sentence recall data. The "co-occurrence index" is defined as the number of times both of any two words from a sentence are recalled divided by the number of times either of the two words is recalled. The co-occurrence

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Insert Table 6 about here

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index means for word pairs drawn from the same proposition and from different propositions are shown in Table 6.[3] A strong form of the Gestalt hypothesis may seem to imply that the co-occurrence index will approach 1 for all same-proposition word pairs. A closer examination, however, will show that this strong prediction only holds when the same words do not play a role in more than one proposition. Three-proposition sentences with four content words necessarily contain words that appear as arguments in more than one proposition. For example, the agent in the BJAV sentences appears in two propositions. Thus, if a subject recalls only the agent and verb from a BJAV sentence the co-occurrence index will be less than 1 even though only whole propositions are recalled. A weaker prediction, which can be justified for the present material, is that the pairs of words from the same proposition should be more likely to co-occur than pairs of words from different propositions. Table 6 reveals that the co-occurrence index means show the predicted trend for every one of the three-proposition sentence types in both integrated and unintegrated forms.

In order to test the strength of the relationship between the proposition membership and co-occurrence, multiple regression analyses were conducted in which the dependent variable was the co-occurrence index of each word pair from a three-proposition sentence, and the predictors were proposition membership (same or different), surface order distance (number of intervening words between the pair members), and conceptual integration. The correlation matrix is shown in Table 7. Proposition membership proved the best predictor of co-occurrence. In a stepwise multiple regression, proposition membership was the first predictor entered, $F(1,59) = 26.8$, $p < .01$. The multiple correlation rose from 0.18 with surface distance and integration as predictors to .28 when propositional membership was added.

Insert Table 7 about here

A HAM representation of each sentence type was developed. The number of intervening links in HAM between word pairs correlated -.0002 with the co-occurrence index. Since in HAM the degree of contingency between word pairs is determined by the number of intervening links, this provides telling evidence against the HAM representation.

In summary, the present data support the hypothesis that propositions, construed in the manner outlined by Kintsch (1974), are the units of representation of sentences in memory. Aspects of the recall of allegedly single-proposition sentences, however, suggest that further refinement of propositional theory is required.

General Discussion

The studies reported here provide compelling evidence for the Gestalt hypothesis that the memory representation for the meaning of sentences consists of holistic units. The first three experiments established that the proposition expressed by a simple SVO sentence is such a unit. The final experiment suggests that propositions such as those defined by Kintsch (1974) are the memory units of complex sentences. A compact summary of the present studies is the following: If a word expressing one of the concepts of a proposition is recalled, then the odds are 9 or more in 10 that the rest of the proposition also will be recalled.

Associative models such as HAM, which represent sentences as collections of independent associations, are fundamentally inconsistent with so high a level of holistic recall. Furthermore, Experiments 1A, 1B, and 2 failed to provide any support for the HAM representational assumption that the verb and object are closer together in SVO sentences than the verb and the subject. Experiment 3 showed that a poor job was done predicting patterns of recall of complex sentences on the basis of HAM-like representations. Finally, a detailed reexamination of the verb repetition and compound cue studies that have also tested associative and Gestalt theory, revealed that these studies either have produced ambiguous results or else have disconfirmed associative hypotheses. As was explained at length earlier (see also R. Anderson & Ortony, 1975; Foss & Harwood, 1975; Jones, 1978), modifications of HAM which have attempted to accommodate

negative results are neither tractable nor consistent with an associative conceptualization. We therefore conclude that the evidence from sentence memory studies now overwhelmingly favors the Gestalt over HAM-type associative theories.

We turn now to another and somewhat different associative theory of sentence memory developed by Jones (1978), which he calls "fragmentation" theory. According to this theory, upon being presented with a sentence, a person encodes a fragment which is any combination of the lexical items of the sentence. The theory is indifferent as to whether a sentence will be encoded in whole or in part, and if in part, which part. Recall of a fragment occurs if and only if it is cued with one of its components. Although fragment recall is regarded as holistic, fragmentation theory should not be confused with Gestalt theory as discussed in this paper. Jones, in fact, argues that the hypothesis is more representative of true associationism than is HAM. Fragmentation theory arose from the direct examination of experimental data whereas, according to Jones, "the design of HAM was greatly shaped by non-experimental factors such as intuitive plausibility and computational feasibility" (p. 366).

Fragmentation theory appears to provide a highly satisfactory account of a range of sentence recall data. For instance, Jones (1978) reanalyzed the results from four sentence memory experiments by J. Anderson and Bower (1973, Chapter 10). In each case, the fragmentation model provided a better fit to the data than HAM, and in only one experiment did the

deviations between predicted and observed values reach significance. Jones also was able to provide fragmentation theory interpretations of the compound cue experiments.

Despite the seemingly impressive array of evidence, fragmentation theory is open to serious challenge. First, and most fundamentally, the theory does not predict what sorts of fragments will be encoded. The composition and relative likelihood of the various fragments is determined a posteriori. Thus, it provides a very weak account of sentence memory vis-a-vis a propositional theory, which in principle, if not completely in fact, specifies a priori what the holistic units will be.

To the extent that fragmentation theory addresses the relative likelihood of the fragments at all, it is inconsistent with the available data. Jones (1978, p. 364) has asserted that the probability that a subject will encode a complete simple sentence (SVO fragment) will vary with the level of learning and recall. In Experiments 1A and 1B reported in this paper, level of learning was manipulated by varying list length. Recall was twice as high in 1B as in 1A, yet the proportion of holistic recall to total recall was the same. In previous research, R. Anderson (1974, p. 540) found that subjects who received imagery instructions recalled over twice as much as subjects instructed to orally rehearse sentences; however, the proportion of holistic recall to total words recalled was the same, namely .96.

The assumption that the relative amount of holistic encoding varies as a function of level of learning was the key to Jones' attempt to interpret the data from the "crossover" experiments. To recapitulate, under the crossover condition, people are cued with the subject and verb of different sentences for recall of an object common to both sentences. Jones argued that fragmentation theory predicted that different-sentence cues could be more or less effective than same-sentence cues. He asserted that the direction of the effect is tied to level of learning. When the level is low, as in the Foss and Harwood (1975) studies, it is assumed that subjects found the sentences too difficult to learn and remember in their entirety. Given this assumption, the fragmentation hypothesis predicts that same-sentence cues will be more effective. When level of learning is high, subjects encode more whole sentence "fragments," and fragmentation theory predicts that the results should be reversed, as originally found by J. Anderson and Bower (1972, Experiment 1).

The research summarized above suggests that the fragmentation theory explanation of the crossover experiments is not tenable. Regardless of level of learning, the amount of partial recall will always be very small relative to the amount of holistic recall. Because this is true, the prediction that can be derived from fragmentation theory (Jones, 1978, p. 364, Equation 6) is that cues from the same sentence will never be as effective as cues from different sentences in evoking recall of a term common to both sentences. Hence, the interpretation of the Foss and

Harwood (1975) experiment, which did show same-sentence cues to be superior, is called into question.

In another type of compound cue study, people have been asked to recall the object of a simple sentence given as cues the subject, the verb, or both the subject and the verb. A prediction from fragmentation theory (Jones, 1978, p. 364) is as follows:

$$P(O|SV) \leq P(O|S) + P(O|V) \qquad (6)$$

The results were consistent with (6) in seven of ten compound cue experiments (J. Anderson, 1976; J. Anderson & Bower, 1972; Foss & Harwood, 1975). Foss and Harwood have shown that this is not much of an achievement, however. In the first place the outcome is a logical certainty when $P(O|S) + P(O|V) > 1$ since $P(O|SV)$ cannot exceed 1. With respect to the range from 0 to 1, Foss and Harwood fit an equation to their own data which indicated that (6) would hold just in case $P(O|S) + P(O|V) \geq .51$. The means from the ten experiments are ordered perfectly in terms of this value. That is, (6) was confirmed in the seven experiments in which the quantity $P(O|S) + P(O|V)$ was more than .51; it was contradicted in the three experiments in which the quantity was less than .51.

The core of fragmentation theory is the symmetry assumption. The probability of recall of a fragment must be the same for each cue that is an element of that fragment, namely the probability that the fragment was encoded. Inspection of Table 1 and 2 reveals that this assumption

was grossly violated by the data of the present studies (see also Gentner, 1977). For example, in Experiment 1A the verb was little more than half as effective at cueing gist recall as were either the subject or object, although all three must be equivalent according to the theory. A final problem is that since fragmentation theory says recall can happen if and only if a fragment is cued by one of its constituents, it is incompatible with studies which have shown that sentence recall can be cued with words that did not occur in the sentence (e.g., R. Anderson & McGaw, 1973; R. Anderson & Ortony, 1975; R. Anderson, Pichert, Goetz, Schallert, Stevens, & Trollip, 1976). In sum, Jones' fragmentation theory provides an unappealing alternative to propositional-Gestalt theory, an alternative which we believe can be rejected.

When one defends, as we do, a strong Gestalt position on sentence memory, the question that must be asked is why any partial recall is observed. The answer is that there are reasonable explanations for occasional failures. First, there is some chance that a learner will mishear or misread a sentence. This may lead to recall of a word that is orthographically or acoustically but not semantically related to the original. A second source of apparent partial recall are intrusions which occur when there is semantic overlap among sentences in a list. An adjusted substance score was developed that discounted orthographic and acoustic confusions, subject-object reversals, and intralist intrusions. With

respect to Experiments 1A and 1B, when the adjusted measure was computed, the level of holistic recall was very high indeed, .98 and .97 respectively.

It is now generally acknowledged that language comprehension is a constructive process and that what people encode into their heads will not always be veridical representations of the sentences they see or hear. Another reason for an occasional apparent fragment in sentence recall arises from this fact. Elements of recall based on a constructed and elaborated representation may not be counted as sufficiently faithful reproductions of the originals. Yet, if a holistic propositional theory is correct, even "intrusions" ought to bear some semantic resemblance to the words they replace. Graesser (1978) has presented an analogous argument about forgetting that also predicts semantic overlap between intrusions and the words of the original. He has reported two experiments that showed the expected overlap. His results provide subtle support for a holistic, propositional theory but are difficult to understand in terms of a theory which says that sentences are represented in memory as colligations of loosely associated concepts. Graesser's work also provides further evidence that the more strict the criteria for judging recall, the higher the incidence of apparent instances of fragmentary, nonpropositional recall.

There remains a hard core of instances of partial recall that involves omissions of sentence elements--that is, cases in which there are blank spaces in subjects' protocols. These are more difficult, but still not

impossible, to reconcile within a holistic, propositional theory. It might be proposed that omissions occur because subjects sometimes edit their output according to strict criteria. Assume that people store in memory both a conceptual representation and some traces for the surface form of the message. Sentence remembering typically begins with the retrieval, or generation, of the conceptual representation. Next the representation is coded into language and there is a check to see if there is a trace for this surface form in memory. If a match can be verified, the verbatim response is made. If there is not a match, the response might be made anyway, resulting in the substitution of a semantically-related word for the literal sentence element. However, under some circumstances, such as when the demand characteristics of the experiment tilt toward literal reproduction of the language of the study sentences, subjects may suppress elements that fail the hypothesized surface form check. There is ample precedent in the human memory literature for a generation-verification mechanism along these lines.

It appears possible to explain instances of fragmentary recall in terms of encoding perturbations such as acoustic confusions, substitutions of semantically-related words that do not meet scoring criteria, and suppression of words that cannot be verified against traces for the surface forms of the originals. The important point, though, is that, whatever is made of instances of partial recall, there are very few of them. In simple sentences and complex ones, ordinary sentences and strange ones,

whether learned well or poorly, whether cued or freely recalled, people almost always recall whole propositions.

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Footnotes

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[1]Nested propositions which, for example, appear in the AVLL sentences were treated according to the following rule: If proposition P_1 is nested in P_2, then P_2 is completely specified if all of the arguments of P_1 are recalled (i.e., P_1 is completely specified) and all additional arguments from P_2 are recalled.

[2]We are grateful to Walter Kintsch for providing his data.

[3]Nested proportions were treated as follows: If proposition P_1 is nested within P_2, then any pair of words both of which appear in P_1 or P_2 will be counted as having occurred in the same proposition.

Table 1

Mean Proportion of Words Recalled, Experiment 1A

Level of Scoring	Word Recalled	Cue: Agent	Cue: Verb	Cue: Object	Cue: Total
Verbatim	Agent	----	.144	.250	.197
	Verb	.193	----	.203	.198
	Object	.263	.148	----	.206
	Both Words	.158	.116	.152	.142
Substance	Agent	----	.165	.300	.232
	Verb	.298	----	.329	.314
	Object	.309	.186	----	.248
	Both Words	.276	.149	.277	.234

Table 2

Mean Proportion of Words Recalled, Experiment 1B

Level of Scoring	Word Recalled	Cue: Agent	Verb	Object	Total
Verbatim	Agent	----	.292	.446	.369
	Verb	.385	----	.380	.382
	Object	.489	.302	----	.396
	Both Words	.340	.260	.308	.303
Substance	Agent	----	.322	.497	.410
	Verb	.506	----	.525	.516
	Object	.532	.328	----	.430
	Both Words	.485	.302	.463	.417

Table 3

Examples of Types of Sentences

One-Proposition	
AVGO	
Integrated	The customer wrote the company a complaint. (wrote, A: customer, O: complaint, G: company)
Unintegrated	The comedian supplied glassware to the convicts.
AVSG	
Integrated	The pilot flew from New York to Los Angeles.
Unintegrated	The pony danced from the theater to the church. (danced, A: pony, S: theater, G: church)
AVOI	
Integrated	The housewife killed the roach with insecticide. (killed, A: housewife, I: insecticide, O: roach)
Unintegrated	The chief marked the building with a rock.
Three-Proposition	
AVAV (Implied)	
Integrated	The baby died and the parents cried. [((died, E: baby) = α) & ((cried, A: parents) = β) & (cause, α,β)]
Unintegrated	The mail arrived and the driver worked.
AVLL or AVTT	
Integrated	The leaves fell during a storm in the autumn.
Unintegrated	The accountant lay in the garden in the mall. [((lay, A: accountant) = α) & (loc: garden, α) & (loc: mall, α)]
JJAV	
Integrated	The pretty young girl flirted. [(pretty, A: girl) & (young, A: girl) & (flirted, A: girl)]
Unintegrated	The bedraggled intelligent model sang.

Table 3 (continued)

AVVV	
Integrated	The batter hit, ran, and scored.
Unintegrated	The engineer donated, drove, and listened. [(donated, A: engineer) & (drove, A: engineer) & (listened, A: engineer)]
JAVL	
Integrated	The famous professor lectured in the classroom. [(famous, A: professor) & ((lectured, A: professor) = α) & (loc: classroom, α)]
Unintegrated	The ragged boots rested on the grating.
BJAV	
Integrated	The dangerously weak staircase creaked.
Unintegrated	The tremendously expensive pickle rotted. [(tremendously, expensive) & (expensive, E: pickle) & (rotted, E: pickle)]

Note: The Kintsch style representation is given in parentheses following one example of each type. Some sentences involved an experiencer (E) instead of an agent.

Table 4

Proportion of Whole Sentence Recall of

Three-Proposition Sentence

	Integrated	Unintegrated
Modifiers	.63	.72
No Modifiers	.78	.63

Table 5

Holistic Recall of Three-Proposition Sentences
by Sentence and Proposition

	Integrated	Unintegrated
AVAV		
Whole Sentence	.86	.71
Propositions		
A_1V_1, A_2V_2	.04	.12
Total Holistic Recall	.90	.82
AVLL		
Whole Sentence	.73	.70
Propositions		
AV, AVL_1, AVL_2	.22	.17
Total Holistic Recall	.95	.87
JJAV		
Whole Sentence	.56	.69
Propositions		
$J_1A, J_2A, AV, J_1J_2A, J_1AV, J_2AV$	.39	.28
Total Holistic Recall	.95	.98
AVVV		
Whole Sentence	.79	.53
Propositions		
$AV_1, AV_2, AV_3, AV_1V_2, AV_1V_3, AV_2V_3$	.19	.35
Total Holistic Recall	.98	.88
JAVL		
Whole Sentence	.76	.77
Propositions		
JA, AV, JAV, AVL	.19	.12
Total Holistic Recall	.96	.89
BJAV		
Whole Sentence	.59	.74
Propositions		
BJ, JA, AV, BJA, JAV	.34	.17
Total Holistic Recall	.92	.91
Total		
Whole Sentence	.72	.69
Propositions	.23	.20
Total Holistic Recall	.94	.89

Table 6

Co-occurrence Index Means for Word Pairs

in Same and Different Propositions

	Integrated		Unintegrated	
	Same	Different	Same	Different
One-Proposition				
AVGO	.844	n.a.	.797	n.a.
AVSG	.858	n.a.	.736	n.a.
AVOI	.810	n.a.	.797	n.a.
Total	.837	n.a.	.779	n.a.
Three-Proposition				
AVAV	.863	n.a.	.835	.661
AVLL	.804	.741	.740	.698
JJAV	.723	.624	.803	.735
AVVV	.851	.832	.636	.605
JAVL	.800	.781	.804	.741
BJAV	.736	.620	.768	.736
Total	.806	.715	.759	.690

Table 7

Correlations of Co-occurrence Index

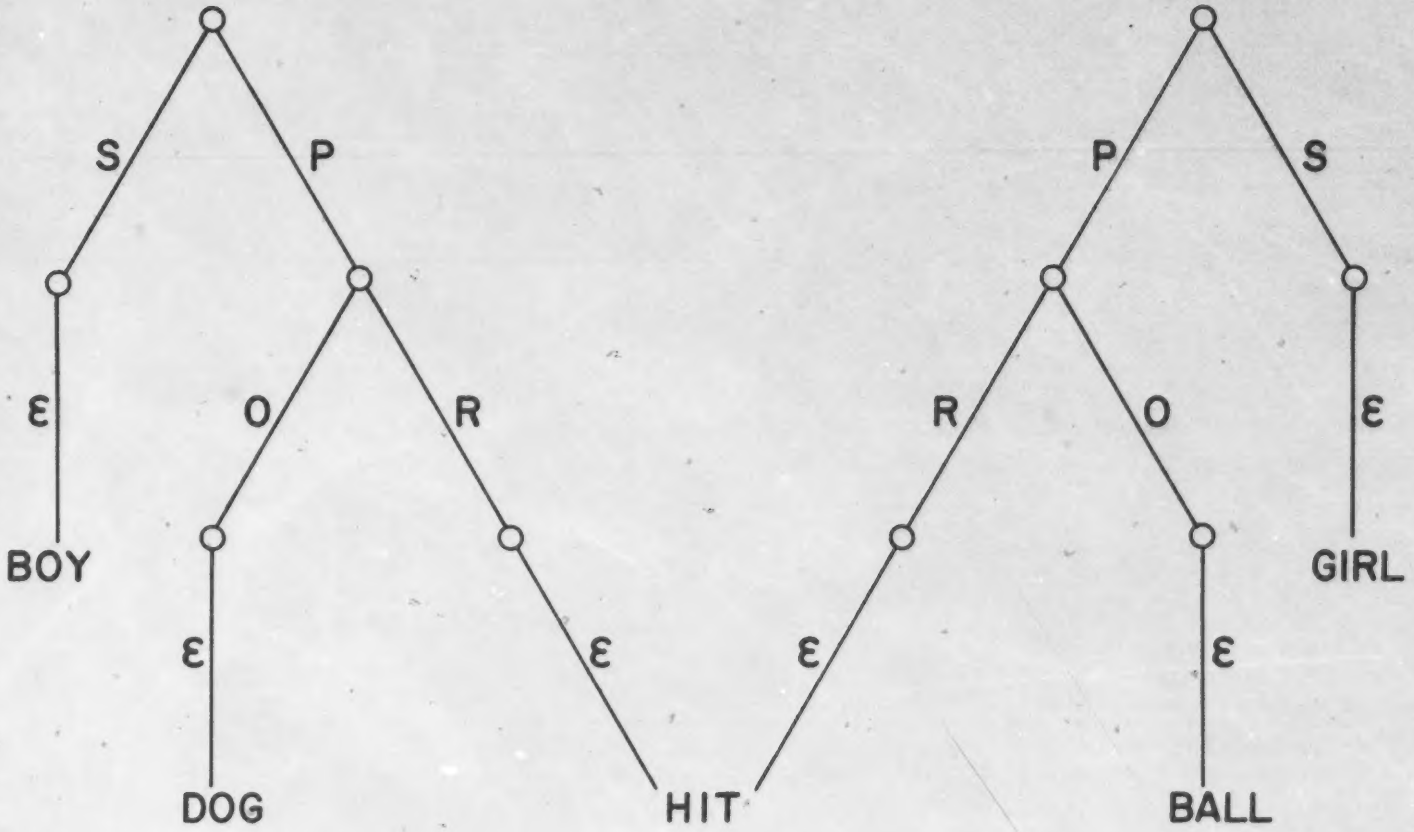
and Sentence Characteristics

Measure	C	I	S	P
Co-occurrence Index (C)	-	.14	.12	.26
Integration (I)		-	0	.14
Surface Distance (S)			-	.33
Proposition Membership (P)				-

Figure Captions

Figure 1. HAM representation of two sentences with a common verb.

Figure 2. HAM representation of two sentences sharing a common object.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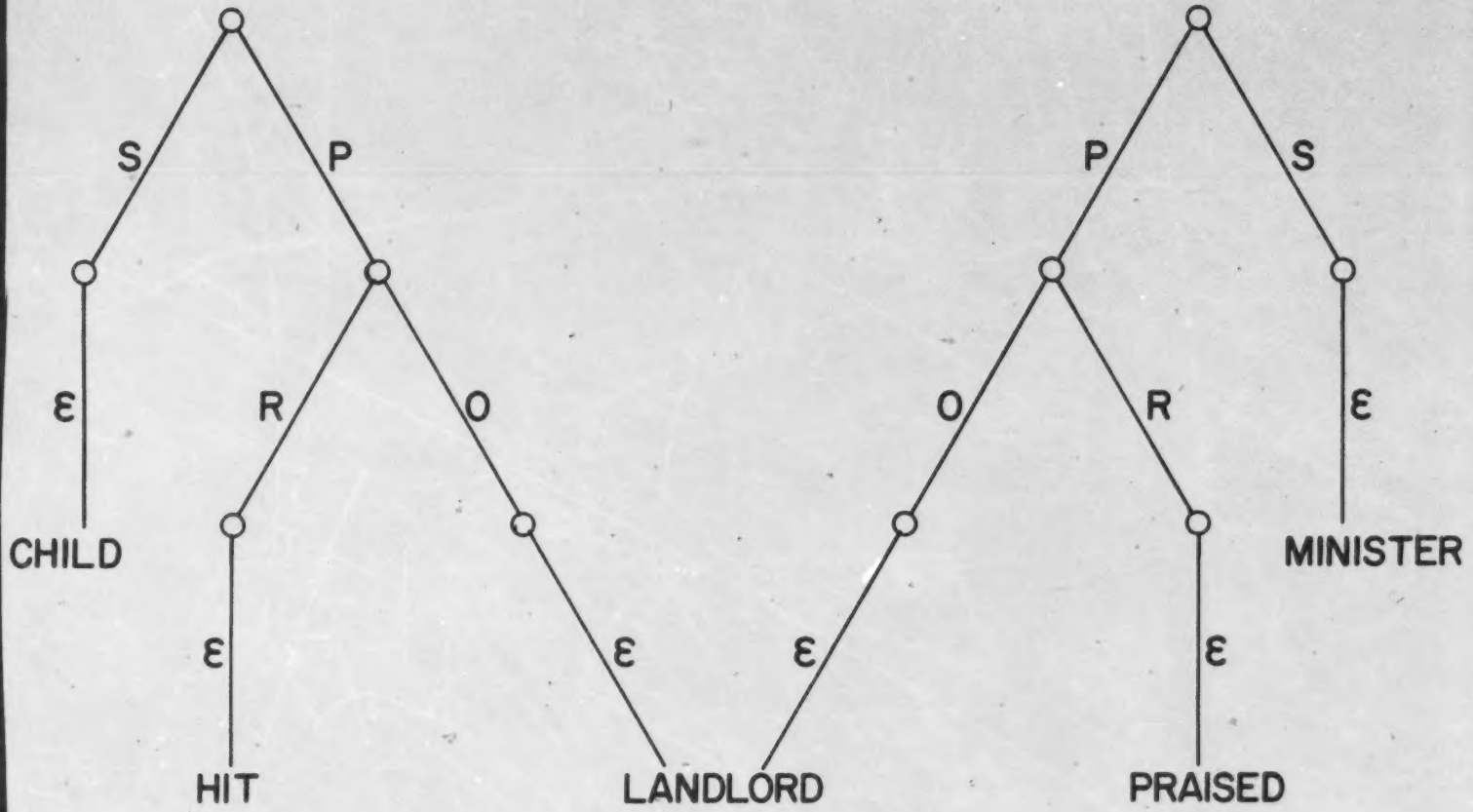
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